Volume 32 May, 1946 *Number 5*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication
of the
Paper Machine

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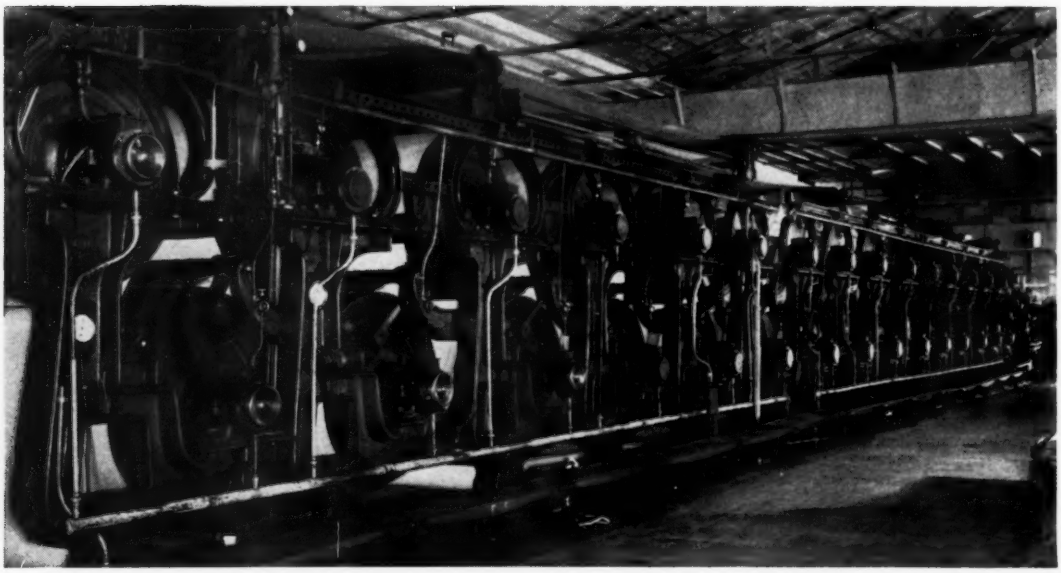

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FOR THE PAPER INDUSTRY

LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Lubrication of the Paper Machine

PAPER MAKING has involved the process of pressing ever since the Egyptians discovered that the papyrus plant furnished thin sheets which could be stuck together and pressed into a uniform sheet which could be used for writing or word pictures. The Chinese, however, came closer to making a product like modern paper when they processed bamboo and rags to produce a flexible material on which their writings could be recorded. Actually they pioneered the art of felting or interlacing wood pulp or cellulose fibres into a homogeneous sheet, which when pressed uniformly and dried, gave a substance which was remarkable for its durability.

The Modern Procedure

All treatment of paper stock up until it is delivered to the stock chest or headbox at the wet end of the paper machine, is of a preparatory nature, to mix, interlace and hydrate the fibres so that they will form a durable sheet or web as subsequent dewatering and drying takes place. The paper machine, with its accompanying auxiliaries — the calender, slitter and winder — constitute the finishing process wherein the paper is actually produced as such. The average paper machine is subjected to a wide range of operating conditions; at the wet end there is excessive moisture and comparatively high pressure; at the dry end, high temperature conditions and heavier pressures prevail. No wonder the paper machine has offered one of the most potential opportunities for improvement in means of lubrication and the adoption of more automatic means of application.

The Importance of Lubrication

In manufacturing lubricants to meet these varied conditions, the effect should be borne in mind during refinement. The oil must be just right to function under the operating conditions to which the modern paper machine is subjected. Heavy duty, high temperatures and moisture demand that modern circulating oils and anti-friction bearing greases be resistant to oxidation and able to protect the working steel surfaces against rust.

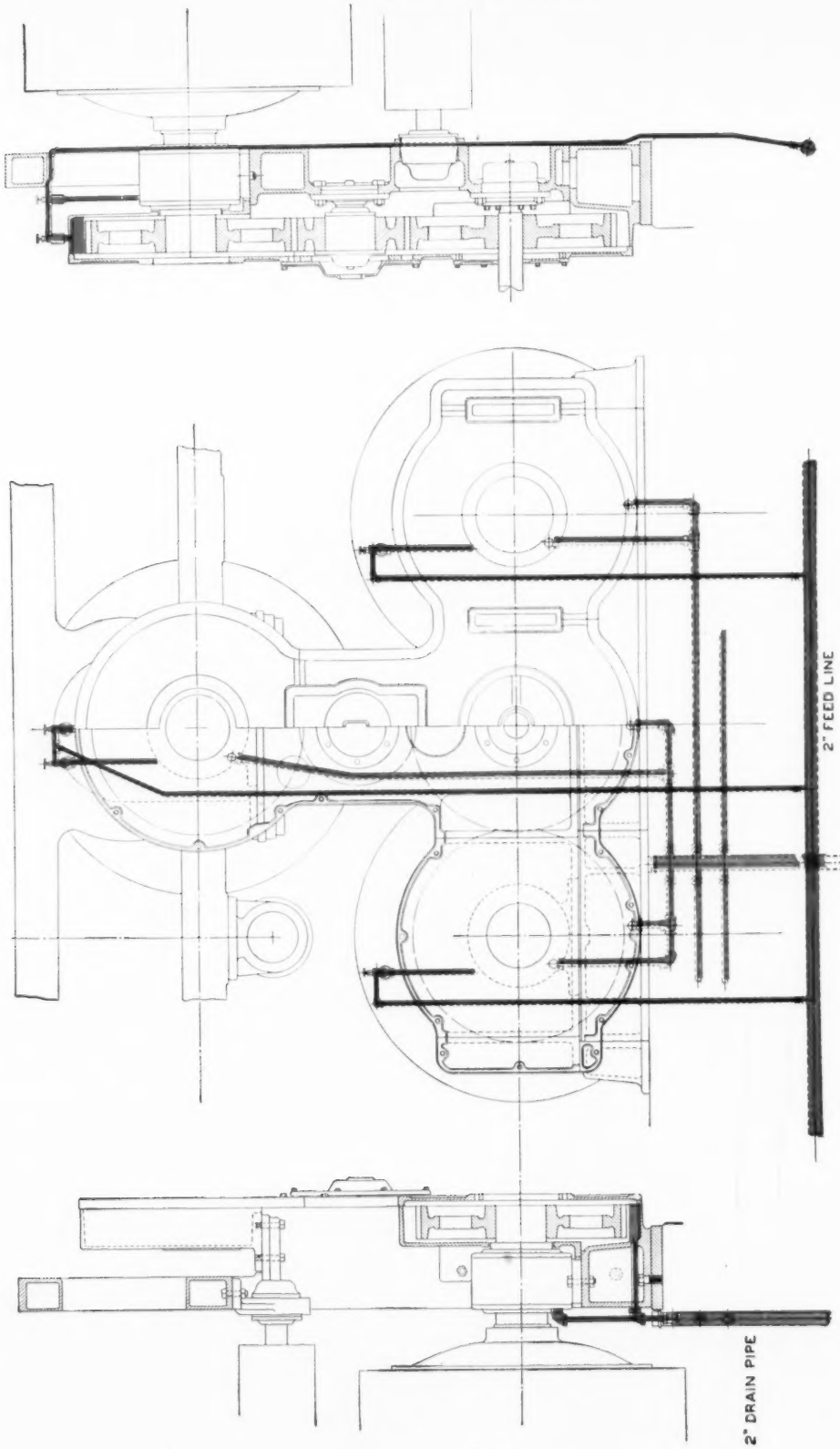
This required cooperative study from the petroleum chemist to the paper machine oiler. At the same time the paper machine has been carefully studied in order to apply better means for lubrication. This involved the designer and the lubricating engineer.

There are essentially two distinct types of paper machines, viz: the Fourdrinier, which is most commonly used for newsprint and the other more familiar grades of paper, and the cylinder or vat machines on which paper board and tissue are produced. It is of interest to review the constructional details.

THE FOURDRINIER MACHINE — WET END OPERATION

Function of the Wire

One of the chief parts is the "wire," a fine copper, bronze, monel or stainless steel mesh endless screen, onto which the paper stock flows from the stock chest or headbox. A partial function of this wire is to enable as much water as possible to drain off as it moves rapidly in the direction of flow. The



Courtesy of The Bagley and Sewall Company

Figure 1—Oil piping layout—back dryer section of a Bagley & Sewall paper machine, showing details of the circulating system to the bearings and gears. Red indicates oil feed lines; green, the oil return lines.

regularity of motion of the wire is most important for upon this will depend its useful life.

A series of parallel table rolls carry this wire and enable the formation of a flat table surface for the first stage in making paper. The first roll of this set is called the breast roll. Below these rolls a saveall is located which collects water drainage from the stock on the wire.

Partial Vacuum is Employed

After the wire has passed over the table rolls, it is led over suction boxes in which a partial vacuum is maintained, to aid in further removal of the water.

During the process of preliminary formation, the embryo layer of paper in some types of machines is prevented from spreading or flowing off the edges of the wire by endless rubber belts, known as deckle straps; these are carried along by the wire. When this latter, with its layer of paper, reaches the last table roll, it passes the layer under a light-weight top roll (called a dandy roll), which smooths the surface of the partially dehydrated sheet.

After this, the stock is passed between a set of couch rolls which add the effects of pressure in squeezing out of some of the water. Since pressure must be available on the top couch roll, its bearings must be so designed as to enable effective lubrication under this pressure. Usually the bottom couch roll is connected through a clutch to a driving unit, serving thereby as the drive for this entire end of the machine. At the couch roll the web of paper is sufficiently bound together by its fibres so that it can carry its own weight.

Then Come the Press Rolls

Since the web can now support itself, it leaves the wire, which is returned to the breast roll over return rolls located beneath the table rolls. The web, in turn, is passed to an endless woolen felt, which carries it between the press rolls. To avoid tearing the web, the pull exerted by the press rolls must be uniformly even and continuous. The number of these rolls will depend on the design of the machine, two or more being used according to the service.

Drive is maintained through the bottom roll, the top elements being weighted in a controlled manner to enable varying the pressure, according to the amount of dehydration to be accomplished. These rolls present the problem of pressure in addition to that of water contamination of the lubricants.

In higher speed machines, suction is also included in connection with the press rolls. There the suction element is known as a suction press roll. It is located below the sheet, serving also as a press roll. In general, the suction press roll carries a perforated shell, containing within itself a stationary suction chamber connected to a suction pump.

THE CYLINDER MACHINE

In contrast to the wet end operation of the Fourdrinier, let's now review the constructional details of the cylinder or vat machine. This latter also employs a wire for the preliminary formation of the web by dehydration or draining. In this case, however, the wire is stretched on a cylindrical framework which rotates in a vat of paper stock. As the hollow cylinder roll revolves, the fluid stock tends to flow through the wire mesh, leaving a deposit of fibrous material on the outer surface of the screen. The drainage flows to a save all.

The difference in level between the water inside the cylinder and the paper stock in the vat develops sufficient suction to build up a considerable web or film of fibres on the surface of the rotating cylinder. This web is then picked up by an endless woolen blanket, or so-called bottom felt, being squeezed into close contact by a top couch roll.

By suitable installation of additional cylinder rolls the web can be built up layer by layer, according to the final thickness desired. While this may involve somewhat of a variation in construction, the essential principles of operation are very similar to those of the Fourdrinier, so they present no real difference from a lubrication point of view, the question of resistance to water wash and pressure being the chief requirements to consider when selecting lubricants.

WET END LUBRICATION

The bearings of the modern paper machine are most carefully designed; many are provided with means for automatic application of lubricants and protection of the latter against contamination. There is no doubt that these advancements have reacted favorably upon the unit cost of lubrication per ton of paper, as well as the cost of maintenance for they more effectively prevent entry of water into the bearing elements and enable the lubricants to resist the pressures involved more effectively.

Where Anti-Friction Bearings Fit In

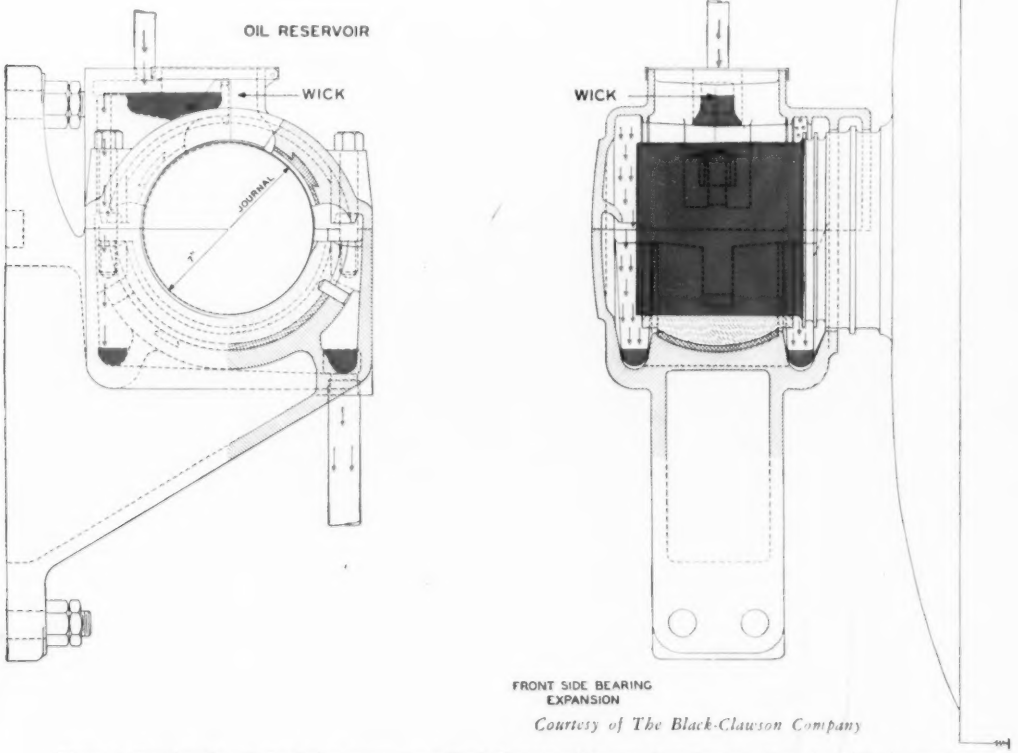
Ball and roller bearings designed for grease lubrication by means of individual pressure gun fittings are applicable to table rolls. Roller bearings in turn have been found to be well suited to press and couch rolls where pressures are higher than on the table rolls. Here, also, pressure grease lubrication is used. The reason for this is obvious; were oil to be used, any leakage would lead to impaired lubrication, not only through possible loss of oil, but

also entry of water, to result in rusting and corrosion of the bearing elements.

Grease, on the other hand, by reason of the construction of such bearings, will normally remain within the latter, and furthermore, grease will serve as a seal to prevent undue entry of water. The relative solubility of a grease for such service, is important. Some authorities prefer a soluble soda soap product since in the presence of normal amounts of water, it will develop lubricating emulsions. There is no reason why this should be an advantage, if high quality lime soap products of medium consistency are properly applied. In fact, a properly compounded non-soluble lime soap grease will retain its original homogeneity and in the presence of average temperatures will develop a good water seal at the ends of the bearings.

700 seconds Saybolt @ 100°F., is also practicable. Compounding enables the oil to develop a suitable lubricating emulsion with sufficient adhesiveness to resist the washing off action of water.

Table roll bearings form an interesting example. Usually they are not subjected to any abnormal pressure, and they operate fairly cool due to the presence of water. Yet, they may contribute to high lubrication and production costs should they tend to drag or stick, to ultimately cause flat spots on the roll itself, due to the friction of the wire. Continued operation under such conditions would not only be costly if table roll replacement is required, but also it



Courtesy of The Black-Clawson Company

Figure 2—Showing the oil circulating system for a Black-Clawson plain type dryer bearing. Note the wick (in green) provided in the oil reservoir in the bearing cap, which feeds oil to the top of the journal. With such an arrangement approximately one pint of oil per minute is circulated through each bearing without flooding. The oil reservoir holds about one quart of oil; this insures that emergency lubrication will be provided temporarily in case of interruption of the main oil supply. Flinger rings turned on the journal cause any drops of oil to drip off or be thrown off, depending upon the speed. The additional rings in the dryer journal and bearing caps tend to prevent dust and lint from working in from the top.

Selecting the Lubricant

Lubrication of the Fourdrinier must be carefully considered regardless of the design or the means of lubrication employed. On most bearings, grease lubrication is preferable. On the other hand, regular application of a compounded oil of from 600 to

might seriously affect the quality of the paper at its most formative stage by interfering with uniformity.

Abnormal wear also will be developed on the wire itself due to uneven tension on the wire, another costly item. Uneven pull with any accompany-

ing wear or tendency in the wire to twist out of shape will ultimately necessitate replacement of this element. The resultant drag on the table roll bearings reacts on the drive, which is ordinarily accomplished through the lower couch roll.

Wick Feed Systems

On plain bearing rolls an automatic wick feed and reservoir oiling device will contribute to effective lubrication since it will not only insure automatic, readily controlled delivery of oil, but also will largely eliminate the uncertainty due to the human element where individual lubrication is necessary. By use of a manifold and circulating system, the operator will be almost entirely relieved of the necessity to attend to such bearings, except where oil reservoirs are to be refilled or wicks stripped.

When a compounded oil is used, wicks should be stripped or cleaned every few weeks to prevent gumming and clogging of the pores of the material. Otherwise free flow of oil would be retarded. Use of too heavy an oil might lead to the same condition.

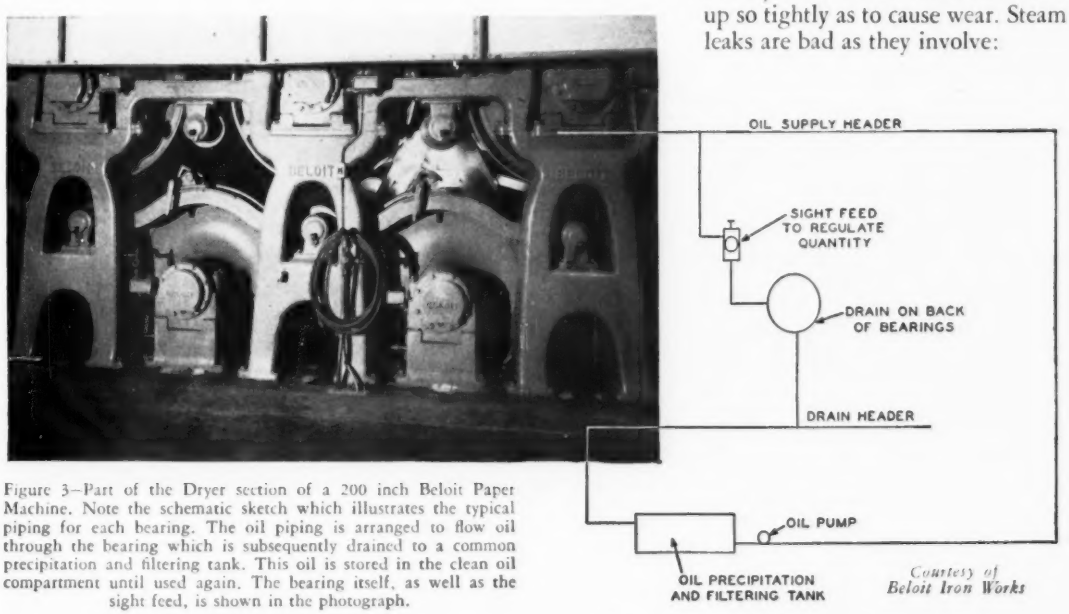


Figure 3—Part of the Dryer section of a 200 inch Beloit Paper Machine. Note the schematic sketch which illustrates the typical piping for each bearing. The oil piping is arranged to flow oil through the bearing which is subsequently drained to a common precipitation and filtering tank. This oil is stored in the clean oil compartment until used again. The bearing itself, as well as the sight feed, is shown in the photograph.

THE PROCESS OF DRYING

The paper sheet as it leaves the wet end of either a Fourdrinier or cylinder machine, after passing through the press rolls still contains at least 60% water. It must, therefore, be subjected to a series of drying operations to render it comparatively air dry. The process of drying involves a continuation of the rolling action already begun on the wet end. At the dry end, however, the roll mechanisms consist of a series of hollow cast iron cylinders, heated internally by steam. On certain types of machines there may be from fifty to one hundred of such dryers.

These elements are built to run in synchronism, being geared together or operated by chain drives in order to function in absolute unison with each other, thereby subjecting the felt to virtually constant tension. The sheet is passed to the first set of dryers directly from the press or felt rolls.

The arrangement of the dryers has a good deal to do with the finished surface of the paper. A method of developing a glaze is to operate one large roll of this nature in conjunction with a series of smaller press rolls. To a certain extent this anticipates the function of the calender stack.

Steam Joints Must be Tight

Steam joints should be checked carefully for leakage; it should be corrected as soon as possible, but a joint should never be screwed up so tightly as to cause wear. Steam leaks are bad as they involve:

1. Loss of valuable steam
2. Water in the bearing oiling system exposing roller bearings to rusting action and contributing to formation of sludges in bearing housings and oil ways
3. Rusting of gears
4. Insufficient drying

Steam joints designed for lubrication can be adequately protected by cylinder oil or grease; the use of either, properly applied to the face of the moving parts will insure proper lubrication, the prevention of wear and consequently steam leakage. The grade of steam cylinder oil employed elsewhere in the

plant will usually be satisfactory for such joints. Steam joints present one of the greatest potential power consuming elements in the paper industry.

Automatic Lubrication Prevails Today

High temperature and pressure may also develop lubrication problems. Very high rotational speeds are not customary (in terms of R.P.M.) although the surface speeds may be high due to the large diameter of the bearings. Furthermore, some bearings are very inaccessible; for example, the bearings on the drive side are frequently almost impossible to reach, due to the driving gears. That's why automatic lubrication has been so widely installed.

The dryer end section of the paper machine offered one of the most promising points for improvement in means of lubrication by application of oil circulation, with provision for adequate and continuous reconditioning. This became all the more apparent with the application of the heavy duty roller bearing and the means which the bearing engineers provided for oil sealing. It involved a mechanism which would benefit materially through oil lubrication, supplied under controlled pressure at sufficient volume to flood the bearings continually, the oil thereby serving as a heat transfer agent, as well as a flushing medium. It only required study on the part of oil filter designers to

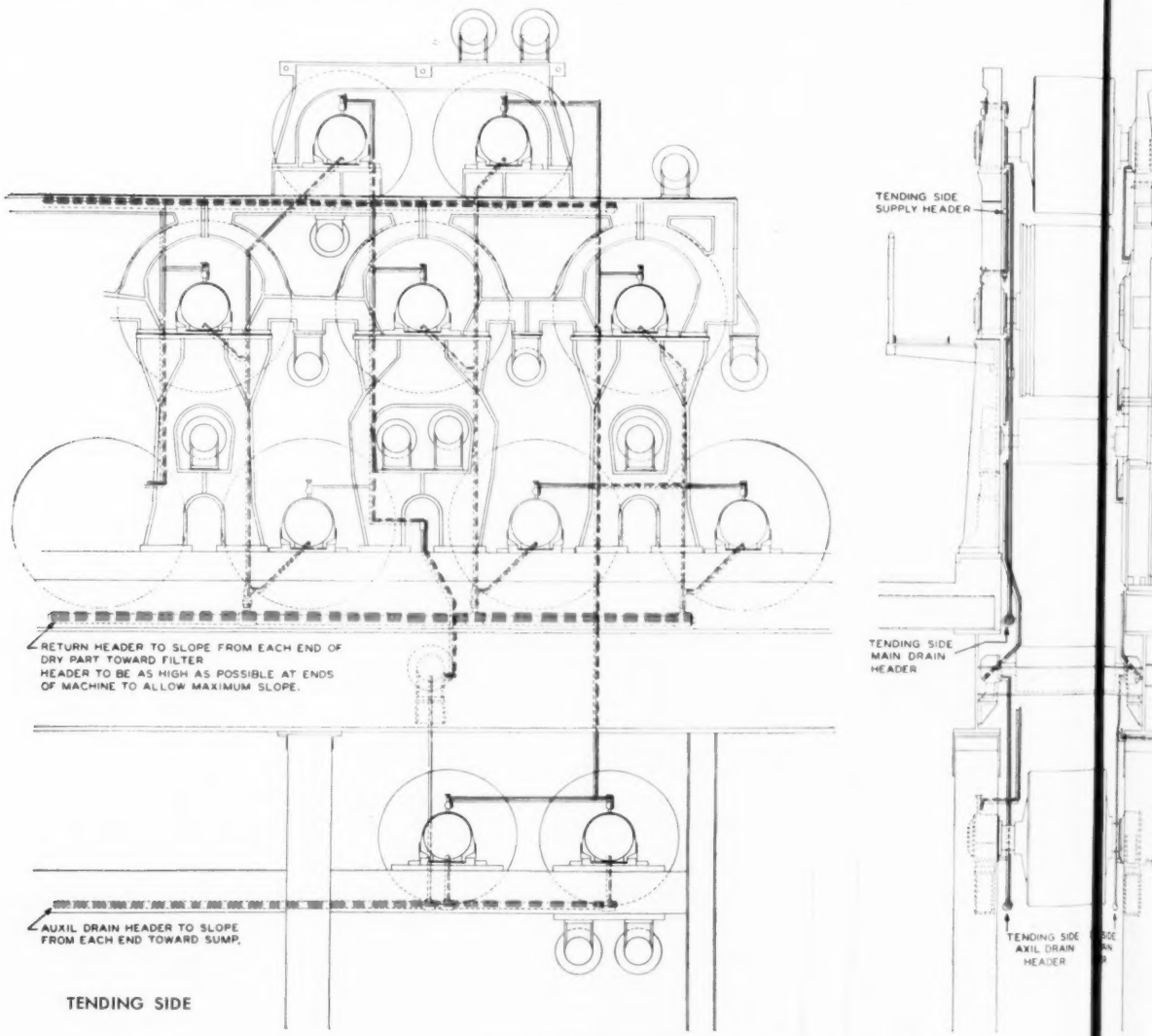

TENDING SIDE SUPPLY HEADER
RETURN HEADER TO SLOPE FROM EACH END OF DRY PART TOWARD FILTER
HEADER TO BE AS HIGH AS POSSIBLE AT ENDS OF MACHINE TO ALLOW MAXIMUM SLOPE.
TENDING SIDE MAIN DRAIN HEADER
AUXIL DRAIN HEADER TO SLOPE FROM EACH END TOWARD SUMP.
TENDING SIDE AXIL DRAIN HEADER
TENDING SIDE

Figure 4—Typical dryer section arrangement of a Pusey & Jones high speed pape[r] showi[ng] bearings and gears; green shows oil drains to the Bowser filtering unit [for] compl[ete]

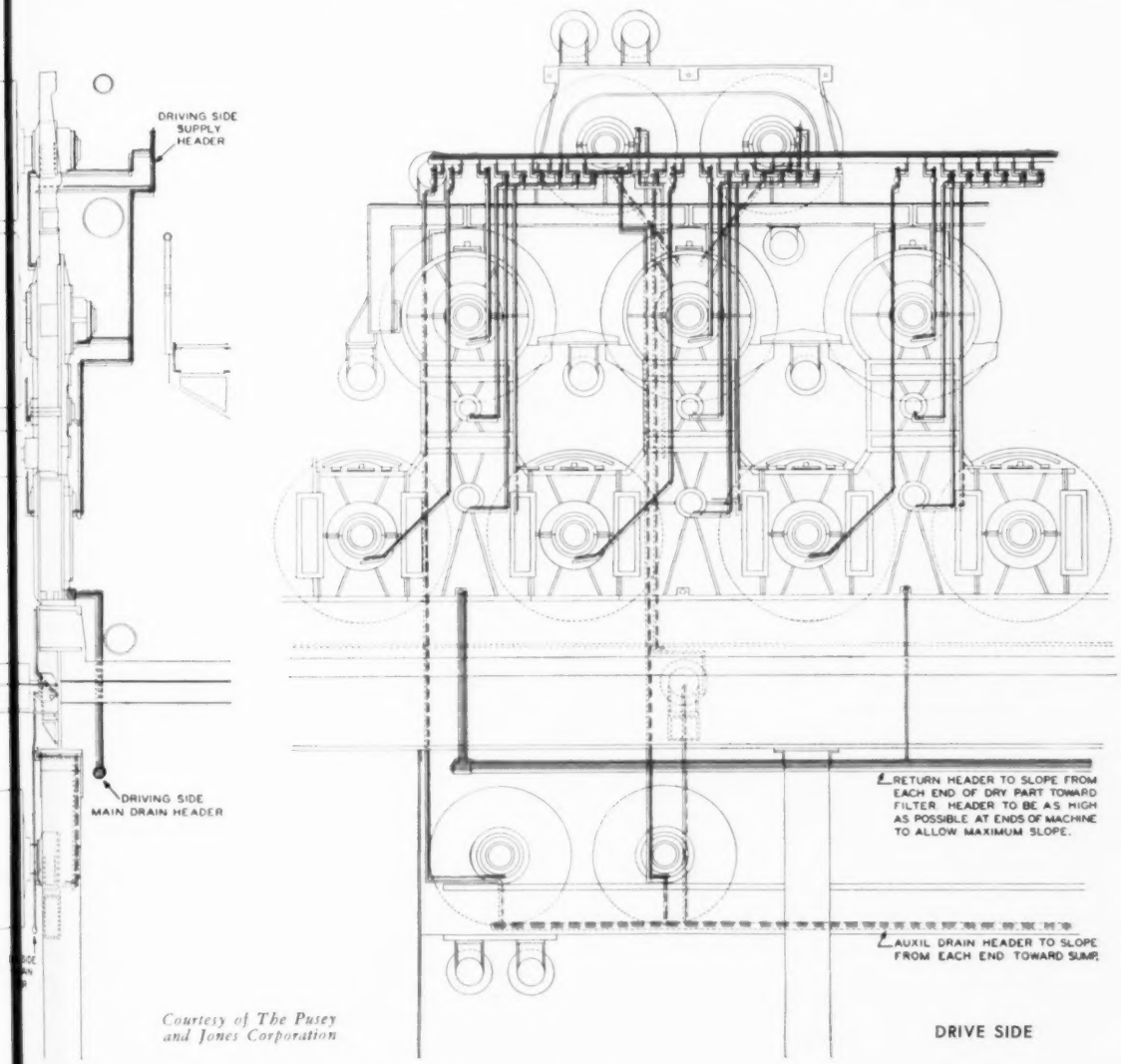
complete the system and maintain the oil in service at a sufficient degree of cleanliness to insure its lubricating ability.

The possibility of oil contamination becomes more remote as the paper approaches its finished state, in passing over the various rolls included in the dryer section. Yet, water may be present if steam joints are leaking. At this point the high temperatures which may prevail also must be considered, especially if the machine is to be run at high speed (in terms of feet of paper produced per minute) to meet high production schedules. Then they literally "turn on the heat" to speed up the rate of drying to conform to the running speed of the machine. Only the highest quality circulating oil, of adequate oxidation resistance, can function dependably under these conditions.

Arranging for Lubrication

The oil circulating system, as designed for the modern paper machine, has required the most careful engineering in planning the distribution and return piping, tankage for the oil storage and filtration unit, and pumps of adequate capacity to keep a full stream flowing through the bearings all the while the machine is in motion.

Temperature control is also an important factor. It is obvious that the circulation of even low pres-


DRIVING SIDE SUPPLY HEADER
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RETURN HEADER TO SLOPE FROM EACH END OF DRY PART TOWARD FILTER. HEADER TO BE AS HIGH AS POSSIBLE AT ENDS OF MACHINE TO ALLOW MAXIMUM SLOPE.
AUXIL DRAIN HEADER TO SLOPE FROM EACH END TOWARD SUMP.
DRIVE SIDE
Courtesy of The Pusey and Jones Corporation

...showing details of the circulating oiling system. Red shows flow of oil to the ... complete details of the bearing construction and gears, see Figure 7.

sure steam through the dryer rolls must lead to a heat condition at the bearings which can be controlled only by the cooling effect of lubrication supplemented by water cooling.

Effect of Impaired Lubrication

Whatever the system of lubrication, it is important to remember that neglect of the back end bearings on any dryer may cause the cylinders to sag, which will in time necessitate undue expense for repair as well as loss of time during the period of shutdown.

These conditions will be prevented, however, if due care is given to study of the several means of lubrication available according to bearing construction, and the choice of a suitable grade of high quality oil. To meet the pressure and temperature conditions this latter should normally be of comparatively heavy body, ranging from 60 to 170 seconds Saybolt @ 210°F., according to the condition of the bearings, the means of application and the temperatures. Ease of distribution is important and might be regarded as the outstanding requirement. On the other hand, the more fluid the product the more readily it may vaporize when exposed to comparatively high temperatures.

The Back Drive

Lubrication of the back drive of the paper machine must always be carefully studied. On some machines the bearings may still be of the plain sleeve type, designed for ring or chain oiling, or grease lubrication. To meet the average operating conditions, these will require an oil of approximately 500 to 750 secs. Saybolt viscosity at 100°F. If the machines have been speeded up, a heavier oil or even a wool yarn or block type grease may be necessary. This is another reason why roller bearings have been applied to more up-to-date back drive construction.

As to the clutch, it is well to state that the magnetic type has of recent years come to replace the older forms of clutch design. In such installations it will be best to use a medium consistency grease, not only for the anti-friction bearings but also for the quills of the clutches; if oil is used there will be a chance of its finding its way to the clutch faces and also to the belts to cause slippage.

Circulating Oiling Systems on the Dryer Section

Circulation of fluid oils under uniform pressure conditions is helpful in reducing operating temperatures through the cooling effect of an excess of fresh cool oil.

Heat is one of the contributing causes of oil oxidation, especially if the oil is exposed to metallic particles. Oxidation is evidenced by sludge accumulations and increase in the neutralization number of the oil. Use of an oil which has been fortified to resist oxidation, insures better resistance to these conditions.

Viscosity is a factor as it is related to the pressure developed by the circulating system, the bearing loads, the temperatures the oil will encounter, and the facilities for reconditioning. One of the predicates of the theory of lubrication is that oil viscosity

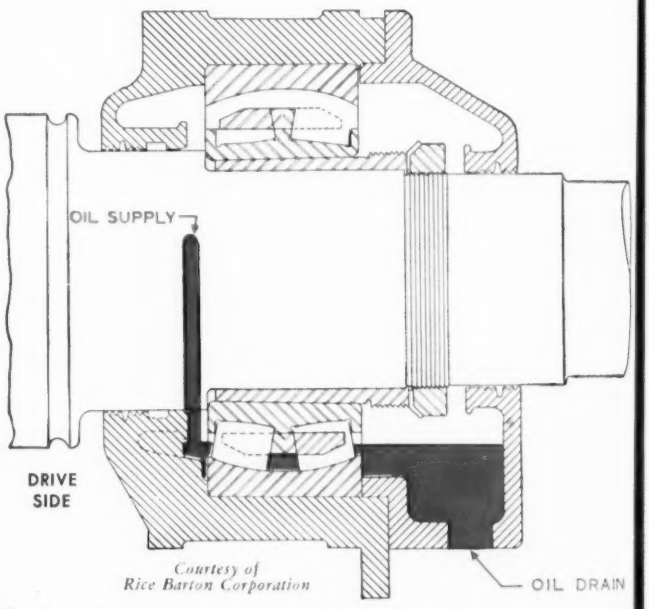


Figure 5—Showing a typical driving side anti-friction bearing as used on a Rice Barton paper machine drying cylinder. Oil route is indicated in red.

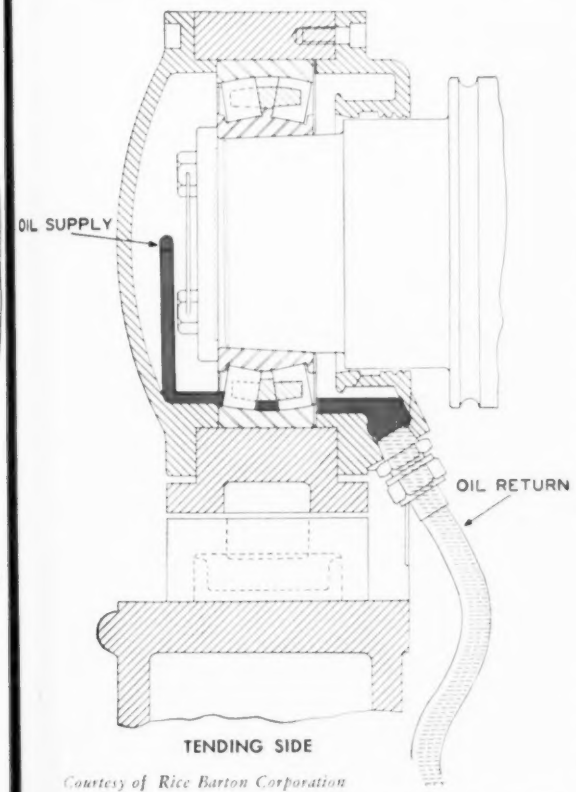
can be reduced as the speed of the rotating parts is increased. So from a speed viewpoint only, it would be right to presume that lighter bodied lubricating oils should be used in circulating systems as speeds increase. Certainly they would serve as more effective bearing coolants in removing surface heat by conduction.

But the matter of bearing pressure also must be considered on many modern machines. This has increased with increase in speed, and heavier loads need greater body in the lubricating film. This requires prior consideration of load-carrying capacity over heat transfer ability, for the latter can be controlled by increasing the volume of oil circulated through the system, and the use of oil coolers.

A variety of combinations for the lubricating system have been developed, ranging from the unit

type of gravity feed system to those multiple outlet devices whereby an entire series of sleeve type or roller bearings can be served by one under the same constant pressure.

The latter has been accepted as a most efficient method of bearing and gear lubrication with the perfection of the heavy duty roller bearing and the oil tight gear housing. The principle is to circulate cool, clean oil under uniform pressure from a central reservoir, to bearings and drive gears to provide proper lubrication and to remove heat from the contact surfaces. This keeps the operating bearing and oil temperatures within reasonable limits. (See page 54.)



Courtesy of Rice Barton Corporation

Figure 6—Showing a typical anti-friction bearing for the tending side of a Rice Barton paper machine drying cylinder. Here, as in Figure 5, oil flow is shown in red.

Pressure Oiling by Gravity

In the operation of a gravity system, the supply pump delivers oil from the settling or sump tank to an overhead supply tank which is mounted high enough to give ample pressure to the gears and bearings. An oil overflow line from the overhead tank to the sump tank returns all surplus oil delivered by the pump. From this overhead tank, a supply header, through an assembly of distributing lines, delivers oil by gravity to the various points to be lubricated; the oil then returns by gravity to the sump tank located below the operating floor.

Gravity circulation reduces the intricacy in construction and the necessity for costly automatic controls, but it is limited in regard to available pressure due to plant conditions. Where this pressure is low, it may influence the choice of the viscosity of the oil.

Full Pressure Lubrication

With this method of lubrication a supply pump delivers oil at a predetermined pressure from the settling tank to a pressure tank in which an air cushion is provided at the top. Usually two pumps are provided, one of which may serve as a spare. This latter cuts in automatically, by means of electrically operated pressure switches when the pressure in the pressure tank drops below a pre-determined minimum, due to failure of the operating pump, or whenever the latter is unable to maintain the desired pressure. If both pumps fail or are unable to maintain sufficient pressure, a third pressure switch, which is set just below the minimum operating pressure required, sounds an alarm.

The expansive action of the air cushion in the pressure tank forces the oil through the main supply line and the numerous branch lines; these are equipped with orifice plates or valves, to provide each bearing or gear unit with its proper share of lubricant. Frequently each of the various points of lubrication are equipped with a pressure switch and light signal to warn the operator, should the oil flow be interrupted. The return oil from the gears or bearings flows back to the settling tank by gravity; here it is subjected to filtration and purification to fit it for recirculation.

CONTROLLED OIL SUPPLY — ITS BENEFITS

Control of the oil supply to the dryer bearings on the paper machine has several beneficial effects; all add up to prolonging the life of the bearings, reducing the cost of maintenance, and keeping down-time of the machine at a minimum. Individually these benefits mean that —

a) *The bearings run cleaner.* This flood of oil washes out potential sedimentary deposits before they have time to accumulate.

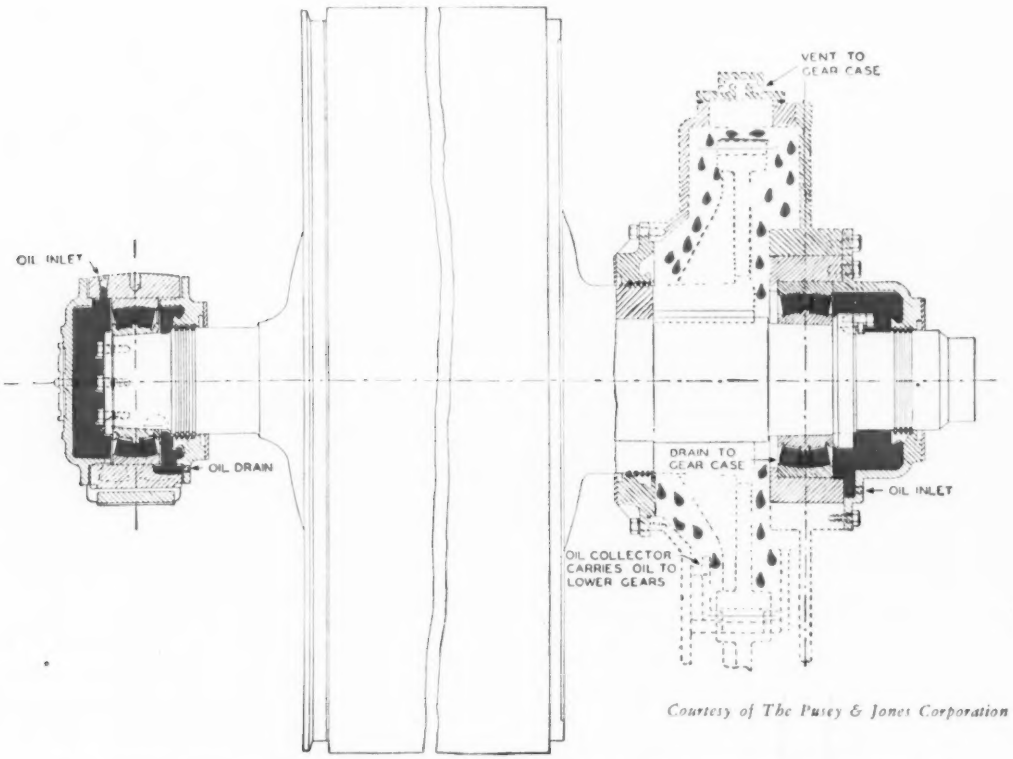
b) *The oil runs cleaner;* circulating more oil more rapidly exposes it to high bearing surface temperatures for a shorter period of time — meaning less temperature rise and chance for chemical action in the oil.

c) *The running temperature of the bearings is lower.* Flooding the bearings with an ample volume of cool, reconditioned oil takes away more heat.

Data to substantiate these conclusions has recently been accumulated on a modern type of paper machine bearing. It appears to associate the rate of oil flow through such a bearing (on the drive side) with the temperatures of the outlet oil and the outer race. For example:

Pints /Min.	*Oil Temp. °F. In*	*Out*	*Bearing Temp. °F. at Journal*	*at Outer Race*
1.3	135	177	280	190
2.7	142	172	280	190
2.95	142	171	280	175
7.2	142	165	280	180

rotated about 270° from the bottom is quite small, since the bearing housing does not maintain any oil level. With the flow increased to three pints per minute, there is a good volume of oil flowing through the bearing at the bottom and the quantity of oil being carried around by the rollers is adequate throughout the entire 360° of rotation. Furthermore, the motion of the rollers picks up some of the oil and causes a little of it to overflow through the overflow outlet in the housing on the side where the rollers start upward. This quantity increases, as the level of the oil increases and as the speed of the journal increases. Maximum flow possible through a streamlined supply pipe to the test bear-



Courtesy of The Pusey & Jones Corporation

Figure 7—Dryer bearing arrangement of SKF spherical roller bearings on a Pusey & Jones paper machine. The bearing housing design allows for free flow of oil, with no chance for accumulation of non-lubricating deposits. The same oil serves the drive gears, as well as the bearings under controlled pressure and in controlled volume.

An oil flow of approximately 3 pints per minute appears to be a good rate to adopt as basic for drive side roller type bearings.

Observation of the action of the oil in a bearing of the type involved which is designed for oil flow straight through the bearing without provision for constant oil level indicates why. With a flow of oil approximating one pint per minute, the level of the oil going through the bearing is quite low and the quantity of oil left on the rollers when they have ing was determined to be 7.2 pints per minute. This is considerably in excess of the volume required. It does not lower the temperature of the outer race, as the data indicates.

Designing for Controlled Oil Flow

During the course of developing this data, certain features of design of the oiling system were weighed and considered to have merit. They involved:

a) Streamlining all circulating oil feeder pipes between the sight feed at the header and the bearing, eliminating 90° and 45° bends wherever possible, which could restrict the flow. This permits the delivery of a greater volume of oil to the bearings.

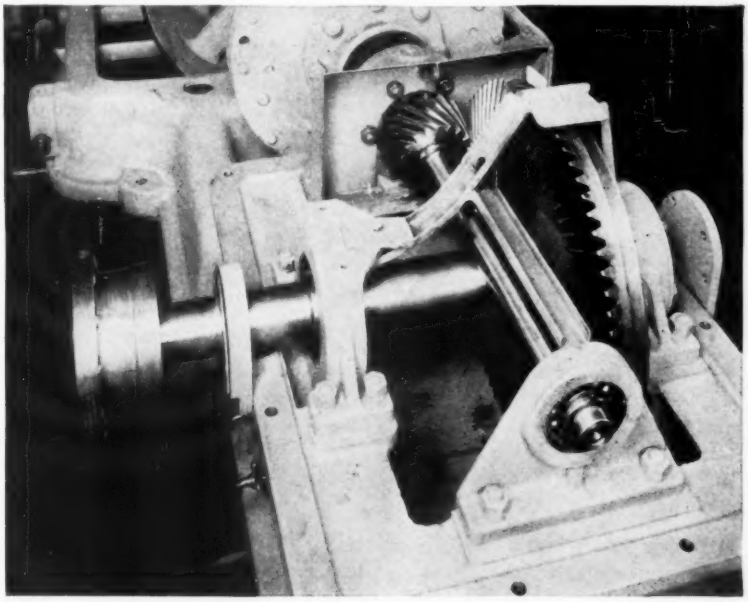
b) Locating the circulating oil inlet on one side of the bottom half of the housing about 45° up from the bottom. This seems to be better than locating it in the bottom of the bearing.

The use of properly located thermometer wells or points for applying pyrometer leads is beneficial so that bearing and oil temperatures can be observed for record. The use of a lucite window in the top half of one or two bearings affords a permanent means for observing the action of the oil in the bearing, the condition of the bearing itself (which can be regarded as typical for the machine) and the relation between the rate of oil flow and the action of the oil in the bearing..

THE ESSENTIAL EQUIPMENT

The Oil Cooler

An oil cooler of ample size is desirable to lower the temperature of the oil leaving the pressure tank. For best results, an ample supply of cooling water must be provided for the cooler, and the latter must be kept clean. Thermometers inserted in the oil lines entering and leaving the cooler indicate the efficiency of the cooler.



Courtesy of Rice Barton Corporation

Figure 8—A Rice Barton hypoid gear unit with cover removed. Note the troughs for conveying the oil to the bearings on the gear shaft as well as the bearing on the end of the pinion shaft.

Oil Filters

Pressure filters installed between the pumps and the pressure tank remove any foreign matter that might remain in the oil drawn from the settling tank. Some have a self-cleaning feature which requires very infrequent dismantling for the removal of the collected foreign matter from the filtering medium.

Centrifugal Purifiers

A circulating system may also include one or more centrifuges which are usually operated intermittently for an hour or so each day. Where large quantities of water may get into the system, however, the centrifuges are sometimes run continuously until the source of the water is located and the leak corrected.

Settling Tanks

With the possible exception of the circulating pumps, the settling tanks are the most useful and necessary features of the circulating system. Where there is any chance of considerable water getting into the system, provision for heating is advisable. Steam coils located in the bottom of the tank can be used for this purpose, to bring the oil to a temperature sufficient to reduce the viscosity and enable the entrained water to settle to the bottom from whence it can be drawn off through the drain valves.

A well-designed settling tank will have several large clean-out ports located along the front and as near the bottom as possible. It is also desirable to slope the bottom of the tank toward the front; then by periodically opening the drain valves, the accumulation of water and sludge in the tank can be held to a minimum. Floating suctions are also often installed to allow the pumps to take the cleanest oil, which is found near the surface of the oil in the tank.

Any settling tank should be of sufficient size to allow the oil to flow through at minimum velocity with ample time for settling; thus the oil entering at one end has an opportunity to drop out a considerable amount of its entrained moisture and con-

taminating foreign matter before it again reaches the pump suction at the other end. The tank should be kept as nearly full of oil as possible, due consideration being given to the expansion of the latter, because a full tank reduces the exposed surface on the inside of the tank and prevents excessive sweating; also it aids in the cooling of the oil, and allows more time for the oil to drop out any contaminants.

GEAR DRIVES

Gear drives are an important adjunct in paper machine operation. Their lubrication, therefore, must be studied with equal care. Normally, such drives are fully enclosed. Where gears are a part of the paper machine itself, as on the drive side, they are lubricated by the circulating oil which serves the dryer roll bearings. Unit gear sets, however, which are part of the main drive for the machine are separately housed and lubricated separately by an oiling system built into the housing or gear case.

Spur gears are used on the dryer roll drives. Spiral bevel or hypoid gears are applied to main drives and calender operation.

On Spur Gears

The anti-rust and anti-oxidation features which are so beneficial in the circulating oil which is used for the dryer roll bearings, are equally beneficial in assuring adequate lubrication of the spur gears which are part of the paper machine drive side assembly.

On Hypoid and Spiral Bevel Reduction Gear Drives

Hypoid and spiral bevel gear drives are unique in that the problem of severe tooth loading and rubbing must be considered. This combination which is more serious in a hypoid drive, can easily cause gear failure if the right lubricant is not used. When a lubrication failure occurs, it is evidenced by welding together of small areas of the mating surfaces of the gears, with resultant scoring or galling. It is caused by:

1. Removal of the protective oil film on the surface of the teeth under high pressure or sliding. The removing of this film will cause contact of clean metal surfaces.
2. The high temperature which is developed in the thin surface oil film when the teeth rub or slide over each other under extreme load.
3. The fact that welding can occur at temperatures lower than the melting point of the metal if the tooth pressure is sufficiently high and the surfaces are oil-free or clean.

Welding can not occur if an anti-welding film is present on the contact surfaces. The extreme pressure type of additive is most capable of forming this protective film on the tooth surfaces. In service such a lubricant functions as:

1. A lubricant in the sense that it provides a fluid film to separate the rubbing surfaces.
2. An agent to build up anti-weld films when tooth pressures and temperatures become abnormally high.
3. A structural guide — in the sense that the ability of the lubricant to give suitable protection is a factor in determining the size of gears for the tooth pressures involved.

The mild E.P. type of non-corrosive gear lubricant is favored for this service. The load-carrying capacity is obtained by blending high quality mineral oils with carefully selected lead soaps in such a manner as to produce compounds of pronounced stability and adhesiveness. The extreme pressure characteristics are permanent; the ingredients do not separate in storage or service; and this type of lubricant is adhesive to the gear teeth even in the presence of an excess of water.

CONCLUSION

Those in charge of lubrication have a most important status in a modern paper mill. Usually they realize this. Most want to be even more important. The lubrication engineer could aspire to the management. Some of his oilers in turn might like to learn to become millwrights or paper makers. To attain these objectives, they all must know a great deal about the paper machine. They must know all the details incident to removal, cleaning and replacing of bearings. They must know the details of the various lubricating systems. They should know how to change the wire, and how to work with the gang when a machine is started.

We have not talked too much about paper making or the details of machine operation in this article. Instead we discussed lubrication, bearings and maintenance. The paper machine is large enough and costly enough to warrant this sort of discussion. We recommend study of the accompanying drawings to convince anyone that the oiler on a paper machine has quite a job.

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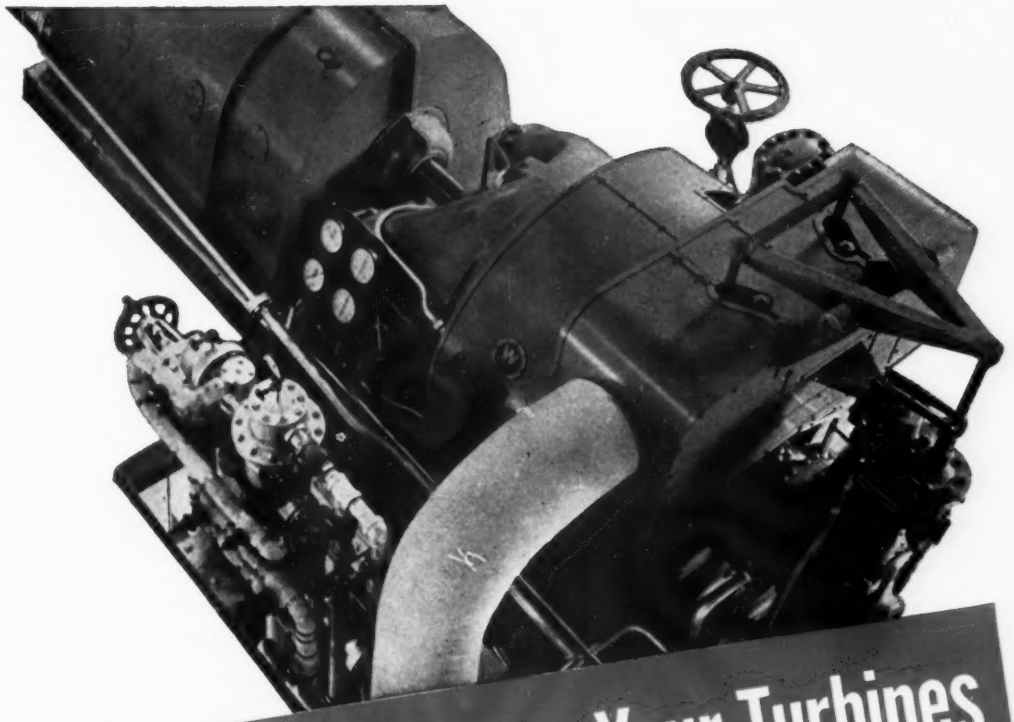

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